operation by which the selected sum was obtained; and an eliminating step of eliminating from the original signal the component of the orthogonal function wave corresponding to the pitch frequency estimated by the estimating step and the components of the orthogonal function waves corresponding to harmonics of the fundamental wave corresponding to the eliminated pitch frequency, wherein a residual component of the original signal which is obtained as a result of the eliminating step is set to a new original signal and each of the above steps is repeated.

According to the invention, there is provided a frequency analyzing apparatus for analyzing a frequency component of an original signal, comprising: spectrum detecting means for detecting, from the original signal, energy levels of components of a predetermined number of orthogonal function waves which have waveforms each having same start position and end position in a predetermined time window and in which the number of occurrences of periods in the predetermined time window or frequencies are different; and orthogonal function wave changing means for changing at least one of the start position and the end position in the predetermined time window each time the energy levels of the components of the predetermined number of orthogonal function waves are detected.

According to the invention, there is provided a frequency analyzing apparatus for analyzing a frequency on the basis of energy levels of components of a plurality of orthogonal function waves detected from an original signal, comprising: operation discriminating means for assuming that one of the orthogonal function waves is set to a fundamental wave, executing an operation to obtain the sum of the energy level of the component of the orthogonal function wave corresponding to the fundamental wave and energy levels of components of a predetermined number of orthogonal function waves corresponding to harmonics of the fundamental wave and having waveforms each having the same start position and end position as those of the fundamental wave in a predetermined time window each time the orthogonal function wave which is assumed as a fundamental wave is switched and of discriminating one of the sums obtained by the operations which is regarded such that a ratio to a total level of the energy levels of the components of all of the orthogonal function waves having waveforms each having the same start position and end position as those of the orthogonal function wave corresponding to the presumed fundamental wave is largest; changing means for changing at least one of the start position and the end position within the predetermined time window every predetermined number of orthogonal function waves having waveforms each having the same start position and the same end position; and estimating means for selecting the largest sum among all of the sums discriminated by the operation discriminating means every predetermined number of orthogonal function waves having the waveforms each having the same start position and the same end position and estimating a pitch frequency from a period or a frequency of the orthogonal function wave corresponding to the fundamental wave presumed in the operation by which the selected sum was obtained.

According to the invention, there is provided a plural pitch frequencies detecting apparatus for detecting each pitch frequency of an original signal, comprising: spectrum detecting means for detecting, from the original signal, energy levels of components of a predetermined number of orthogonal function waves which have waveforms each having same start position and end position in a predetermined time window and in which the number of occurrences of periods in the predetermined time window or frequencies are different; operation discriminating means for assuming that one of the orthogonal function waves regarding the energy level which is obtained by the spectrum detecting means is set to a fundamental wave, executing an operation to obtain the sum of the energy levels of the components of the orthogonal function waves corresponding to the fundamental wave and energy levels of components of a predetermined number of orthogonal function waves corresponding to harmonics of the fundamental wave and having waveforms each having the same start position and end position as those of the fundamental wave in a predetermined time window each time the orthogonal function wave which is assumed as a fundamental wave is switched and of discriminating one of the sums obtained by the operations which is regarded such that a ratio to a total level of the energy levels of the components of all of the orthogonal function waves having waveforms each having the same start position and end position as those of the orthogonal function wave corresponding to the presumed fundamental wave is largest; changing means for changing at least one of the start position and the end position within the predetermined time window every predetermined number of orthogonal function waves having waveforms each having the same start position and the same end position; estimating means for selecting the largest sum among all of the sums discriminated by the operation discriminating means every predetermined number of orthogonal function waves having the waveforms each having the same start position and the same end position and estimating a pitch frequency from a period or a frequency of the orthogonal function wave corresponding to the fundamental wave presumed in the operation by which the selected sum was obtained; and eliminating means for eliminating from the original signal the component of the orthogonal function wave corresponding to the pitch frequency estimated by the estimating means and the components of the orthogonal function waves corresponding to harmonics of the fundamental wave corresponding to the estimated pitch frequency, wherein a residual component of the original signal which is obtained as a result of the eliminating means is supplied as a new original signal to the spectrum detecting means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing an outline of a main construction of a pitch detecting apparatus according to an embodiment to which the present invention is applied;

FIG. **2** is a flowchart showing the frequency analyzing operation according to an application of GHA which is performed in a frequency spectrum analyzing unit in the pitch detecting apparatus of FIG. **1**;

FIG. **3** is a diagram showing one of the kinds of orthogonal function waves which are used in a frequency analysis that is executed in the frequency spectrum analyzing unit in the pitch detecting apparatus of FIG. **1**;

FIG. **4** is a diagram showing another one of the kinds of the orthogonal function waves which are used in the frequency analysis that is executed in the frequency spectrum analyzing unit in the pitch detecting apparatus of FIG. **1**;

FIG. **5** is a diagram showing a list of periods of the orthogonal function waves which are used in the frequency analysis that is executed in the frequency spectrum analyzing unit in the pitch detecting apparatus of FIG. **1** in the case where an analysis length is equal to the even number of samples;

FIG. **6** is a diagram showing a list of periods of the orthogonal function waves which are used in the frequency